



## AN ECOLOGICAL STUDY OF THE SALTMARSH VEGETATION IN THE PORT JACKSON DISTRICT.

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(Plates xvii.—xxx.)

### *Introductory.*

Plant ecology embraces the environmental conditions relative to plant distribution and adaptation throughout the world. Such a study can only deal with broad generalisations, hence the necessity for the critical survey of small areas in which detailed observations of the behaviour of the vegetation may be conducted. The results of these investigations, though primarily of purely scientific interest, should provide much valuable economic information. Forestry has already been termed applied ecology, our native fodder plants are under consideration from an ecological standpoint by local workers, and all branches of agriculture must eventually benefit by the knowledge thus acquired of both plant and habitat. To the systematic botanist a knowledge of the structural modifications imposed upon plants by environmental conditions is of extreme importance.

### *Factors and Response.*

The most potent factors affecting plant life in the local marshes are the presence, in quantity, of sodium chloride in the soil, intense insolation, imperfect drainage, tidal and stream movement. The dominance of these agencies has resulted in the production of a flora specially organised to resist their injurious influence, plants with xerophytic structures attaining the maximum of success. *Salicornia australis* Sol., the largest local herbaceous formation, has adopted the protective device of succulence; the Grey Mangrove, *Avicennia officinalis* L., deflects the light and minimises the effects of extreme insolation by presenting a glossy leaf surface to the solar rays; the Swamp Oak, *Casuarina glauca* Sieb., is practically leafless, and the vertically arranged, highly cutinised, cylindrical stems of the reeds are well adapted to withstand the deleterious factors operating in the marsh. The

common vegetative response to bad drainage is shallow rooting; the Grey Mangrove also reacts to imperfect oxidation by the production of special breathing organs (1). Massed assemblages, with a rhizomatic connection and tolerance of the deposit of considerable quantities of silt on their formations, are characteristic adaptations of our marsh plants to resist tidal and stream invasion.

#### *The Habitat.*

The local marshes are the result of hydrodynamic action, stream and tide each bearing its quota of soil particles to form a mud bank at the head of the estuary. When the alluvium, usually a clayey deposit, has attained an altitude upon which vegetation may exist, floating seeds of the Grey Mangrove settle on the mud and the surface is eventually covered with a forest of these trees. By obstructing the tide and stream flow they compel each in turn to deposit a portion of its burden of silt in their immediate vicinity, thereby accelerating the uplift of the marsh. The landward margin of the marsh is built up by stream deposit and as the banks advance upon the plain, the halophytic vegetation is driven seawards, until it reaches the region where the tidal scour is sufficiently energetic to preclude further encroachment. In many local marshes the littoral margin is moulded into a crescent by the sweep of the tide, and frequently bisected by a channel flowing inland and connected more or less directly with the stream formed by the drainage collected in the adjacent country.

The littoral soil consists of loose black mud, whose stabilisation is largely the work of Algæ which form a filamentous network on the surface, and eventually provide a modicum of humus for the succeeding herbs. This muddy area is frequented by a crab, of which Mr. C. Hedley (18, p. 46) writes: "Between the falling and the rising tide, it burrows and builds with such energy that the whole field is covered with little pits and heaps of mud pellets like worm castings on a lawn." The analogy may be advanced a step further, as the crabs perform a similar beneficent service in the aeration of the marsh mud to that undertaken by the earthworms in ordinary garden soil. The various formations, by collecting soil and debris, finally raise the marsh until it becomes unfitted for their further occupation and are eventually destroyed by the conditions in whose production they have played such a prominent part.

*Zonation.*

The zonal system in our marshes is largely regulated by the edaphic conditions, in which soil salinity and the degree of submergence play a prominent part. The muddy, tide-flooded area on the marsh littoral, followed by a barren stretch of saltplain, with its detritus heaps and shallow pools and channels, and the marginal zone, with a reduced soil salinity consequent upon the spread of the fluvial stream over the surface, each form distinctive stations occupied by selective formations. The dominant arboreal species, the Grey Mangrove and the Swamp Oak, occupy, respectively, the seaboard of the marsh and its landward margin, herbaceous formations clothing more or less effectively the intervening area. The curvature of the marsh on its littoral front has necessitated the adoption of a semicircular, or horseshoe-shaped, zonal arrangement by the various formations, each in succession forming a border, more or less regular, on its neighbour's boundary. The formations in the centre of the marsh expand radially, those on the landward side narrowing into elongated bands and extending bilaterally. The detrital uplift of the landward bank and its forward movement on the plain dislodge the marginal formations, either suppressing them, or driving them towards the centre of the marsh, and replacing them with the series next in the line of succession.

The creeping, or carpet-forming, perennial herbs—grasses, etc.,—which constitute the major portion of the vegetation in the marginal zone, are annually intruded by ephemeral ruderals, which consummate their life-history during the resting period of their hosts, the cycle closing contemporaneously with the arrival of the season of activity of the permanent plants. Monocarpic herbs of longer than annual growth also enter these formations, their (usually) vertical roots operating in a sphere complementary to those of the perennial rhizomatic species.

*Special Features.*

The distinctive note in the saltmarsh proper is uniformity, the vegetation covering large areas of our marshes maintaining a strikingly symmetrical arrangement, the principal formations displaying an even contour level and a decided zonal boundary, though, in sections where the physical factors operate irregularly, salients of greater or lesser depth are formed on their lines of division, and the shapeless detritus heaps on the salt plain are occupied by variform assemblages. The landscape of the

marsh is the joint production of the mangrove forest and the *Salicornia* meadow, the latter, with its monotonous stretch of dull-green, stunted herbage, framing the mangroves with a sombre border. The lack of diversity is due to the harsh conditions obtaining in this exclusive station, which have limited the vegetation to a few species. The portion of the plain lying between the *Salicornia* and the marginal formations is broken by scattered detritus hummocks and ridges, and intersected by water channels and occasional pools which harbour a weak scanty herbage, the remnants of several communities. Large stretches of this inhospitable station are bare of vegetation, except where clothed with a filamentous algal deposit, the surface, in the lengthy intervals between tidal visitations, becoming sun-cracked and flaked (Plate xxiii., fig. 13) or, in places, encrusted with a glistening coat of salt (Plate xxiii., fig. 14). The marsh plain is frequently fringed by reed formations which extend along its margin in elongated bands (Plate xvii., fig. 1), their tall, closely-ranked stems providing a pleasing alternative to the degenerate herbage of the salt plain.

In several local marshes the Swamp Oak occupies a position on the plain boundary, lining its banks in a belted avenue, or spreading into a forest on the fluvial mud flats at the head of the marsh. This quaint tree lends a picturesque character to the scenery, with its ascending tufts of ashen grey branchlets, encircled at their joints by toothed whorls of rudimentary leaves and the rough corrugated bark usually draped with varicoloured lichens. Tea-trees, *Melaleuca* spp., form the bulk of the shrubby undergrowth in the *Casuarina* forest (Plate xxvi., fig. 19) their heath-like foliage blending harmoniously with the narrow cylindrical branchlets of their taller associate. The loose, smooth, papery bark of the Tea-trees presents a marked contrast to the wrinkled compact cortex of the Swamp Oak.

The outlying formations are less regular in outline and volume than the central groups. The scarcity of mosses, noted by ecologists as exceptionally halophobous, was observed in the local marshes. The lichen flora on the contrary is well represented, chiefly on the *Casuarina* trunks. Though occasional on the mangroves exposed to the light at the fringe of the forest, the lichens are unable to penetrate its heavily canopied interior. Rosette-forming species are rare in the tide-flooded zone and on the salt plain, though the detritus heaps occasionally harbour the

introduced 'Rib-herb,' *Plantago lanceolata* L. or *P. coronopus* L. The endemic rosetted *Droseras* and *Goodenias*, common in swamps and peat bogs, are absentees from the saline stations in the marsh. Bulbous plants, crown-forming species, and herbs with a tuberous root-stock are also infrequent in these stations. The absence from the local marshes of the vines and varied shrubby vegetation common in tropical estuarine marshes is conspicuous. In the marsh proper the indigenous flora predominates, but in the fluvial zone on its boundary the foreign element is more evident.

#### Floristic.

The floral element is unobtrusive, the absence of bright colours emphasising the distinction between the xerophytic marsh plants and the ericoid xerophytes of the neighbouring sandstone hills, with their wealth of gay blossoms, the prominent species in the marsh displaying small or neutral-tinted flowers. The inflorescence of the Grey Mangrove is dull and inconspicuous, consisting of sprays (cymes) of flowers with yellowish-red petals, frequently hidden in the luxuriant foliage. The River Mangrove, *Aegiceras majus* Gaertn., which makes a more presentable display, is not well represented in the local marshes. The flowers of the *Salicornia* are immersed in the succulent fertile stems, the anthers when ripe protruding from the narrow foliar collar surrounding the joints. The floral envelopes of the Seablite, *Suaeda maritima* Dumort., and other chenopods are green, the minute flowers clustered round the stem, or half hidden in the axils of the leaves. The dingy yellow flowers of the New Zealand Spinach, *Tetragonia expansa* Murr., are also inconspicuously disposed. The horizontally arranged flowers of *Selliera radicans* Cav. are streaked with drab-coloured splashes, and the Spurrey, *Spergularia rubra* Camb., *Lobelia anceps* Thunb., and *Wilsonia Backhousii* Hook. f. have small unattractive flowers. *Samolus repens* Pers., a species with a minor representation in the marsh, has bright starry flowers, but they are usually hidden among the taller herbage through which the plants creep. *Cotula coronopifolia* L., a lowly herb which attains its optimum at the junction of the fluvial and saline stations, makes a display of bright button-like flowers, which arrest attention by their disparity with the prevailing lack of colour rather than their intrinsic beauty. A large proportion of the marsh plants are wind-pollinated, and the paucity of species with bright

coloured flowers is complementary to the absence of insects. The rarity of coloured fruits is also notable.

A feature of the colour scheme in the marsh remarked by numerous writers is the occurrence of chromatism in the stems or leaves of certain plants, more particularly *Salicornia*. The red colouration is generally attributed to the presence of anthocyanin, and various hypotheses have been advanced in explanation of the phenomenon, e.g. environmental—extreme salinity (3, p. 337), a dry station (4, p. 350); phenological—red in autumn (39, vol. 16, p. 189), red in winter (24); heredity—transmission from parent to offspring (22, vol. 8, p. 102). Tufts of *Salicornia* were noted by the writer bearing both red and green stems in all stations in the marsh and at all seasons of the year. The percentage of red stems was lowest in summer and reached the maximum at midwinter. In June the marsh plain at Homebush Bay had acquired a purplish tint owing to the prevalence of coloured stems of the *Salicornia*. The Sea-blite, which was also affected, showed a slight increase only in the proportion of coloured herbage during the winter season. Other plants in the local marshes which have developed chromatism are—*Spergularia rubra*, *Atriplex patula* L., *Mesembryanthemum aequilaterale* Haw., *Polycarpon tetraphyllum* Loefl., *Rottbellia compressa* L. f., *Haloragis micrantha* R. Br., *Rumex acetosella* L. The latter is noted as "Often turning red."\*

#### Taxonomic.

In systematic botany the floral structure is important, but in ecology the growth form is the consequential character. The role of ecology in systematic botany has been considered by various writers, and numerous instances of species and varieties whose morphology has been affected by the formative factors dominating their environment have been recorded. Of *Atriplex patula*, Miss Cross (7, p. 550) says, "In the dried parts of the meadow the leaves are smaller and very rarely hastate; sometimes they are almost sessile. In the marshes the leaves reach their greatest size, and have the typical hastate shape."

The extremely diverse factors operating in contiguous stations in the marsh have left their impress on this exceptionally plastic species, which is well represented locally. Its behaviour in our marshes is similar to that noted by Miss Cross, the leaves ranging from narrow ovate to rhombic and hastate, in the passage of

\* Fl. Austr., v., p. 265.

the plants from a dry station on the marsh margin to the muddy zone, their habit also gradually developing from a prostrate to an erect stature. Several forms of *A. patula* have been described as species, sub-species or varieties, but the evidence obtainable in the local marshes points to a common origin, though the resultant forms are dissimilar in leaf structure and habit of growth. Further taxonomic references to halophytic plants will be found in (3), (5), (14), (20).

#### *Seed Dispersal.*

Of the three principal agencies—apart from man—engaged in seed distribution, viz., currents, birds, and winds, the former plays the most important part in the local marshes, the newly-formed mud-bank—the future saltmarsh—depending exclusively upon water carriage for its afforestation by the mangroves. Plants also occur whose fruits are embedded in the stems which disintegrate and float on tide or current disseminating the seeds. The capacity to germinate in salt water and float for a period in the seedling stage—a special feature of the tropical mangroves—is also characteristic of the seeds of several local species. The large fruits with buoyant fibrous tissue, common in tropical estuaries, are not found in the local marshes, the majority of the plants producing small fruits or seeds with a brief flotation. The albuminous seeds of the grasses and sedges are probably the most tempting diet offered to visiting birds, fleshy baccate fruits being conspicuously absent from our marshes; the insignificant berries of the Sea-blite provide the best example of succulence among the indigenous species. Plants were noted whose seeds emitted a sticky mucus when wet, which would cause them to adhere to the feathers of birds and facilitate their dispersal.

Typical wind-dispersed seeds are the dust-like spores of the lichens clothing the trunks of the Swamp Oak, which are launched on their aerial flight from elevated positions. None of the indigenous marsh Composites are provided with wind-disseminating pappus, but several introduced members of this family are dependent on their parachute of bristles for distribution. Though the wind is less responsible for seed dispersal in our marshes than either birds or currents, it enacts a beneficent role in pollination in this station, where insect life is infrequent, the reeds and grasses, among herbs, and the swamp Oak, representing the arboreal species, relying upon the wind for this in-

dispensable office. Numerous references to the flotation and germination of the seeds of plants represented in the local marshes will be found in (13), (14), (15), while viability tests of seeds of plants herein noted are tabulated by Ewart (11) and Rees (35).

### *The Formations.*

#### 1. *The Tide-flooded Zone.*

The vegetation of the tidal zone is furnished chiefly by the Grey Mangrove and the *Salicornia*, supported by a series of low succulents and salt-grasses, with a background of closely-regimented reeds. In the marsh, this zone is bounded by the barren salt plain, but on the landward margin the tidal formations follow the bank inland until they reach the fluvial zone. The Grey Mangrove, an umbrageous tree which forms dense forests on its seaboard, is the pioneer colonist of the saltmarsh. In many of the local estuarine marshes the mangroves spread outwards across the tideway, following inland, in belted formation, the banks of the customary drainage channel flowing through the centre of the marsh. The extension of the Mangrove forest is strictly limited by the depth of the tidal waters, its entry into the bay usually taking the shape of a crescent encircling the area at the head of the muddy basin lying behind the permanently flooded expanse of the bay, which is exposed at low tide. Inland, the trees which have followed the course of the channel to its broken headwaters, display, in a marked manner, loss of size and vigour as they approach the shoals. Typical examples of this graduated dwarfing occur in the marshes at Homebush Bay (Plate xxii., fig. 12) and Cronulla, the reduction in stature commencing where the dilution of the tidal water by the fresh water from the inland drainage channels becomes effective.

The root system of the adult Mangroves is shallow, radiating horizontally and beset with the characteristic asparagoid pneumatophores, which indicate the course traversed by the roots from which they arise. In addition to fulfilling their well known function of aeration, the breathing roots afford a powerful stay to the Mangroves, their partially embedded stems offering a stout resistance to the wash of the tide. Incidentally they collect a considerable quantity of detritus and play a prominent part in the uplift of the marsh.



The deepening of an arm of Cook's River, which traverses the sewage farm near Arncliffe, has isolated a group of Mangroves from their normal habitat, and left them stranded on a part of the marsh now drained by the channel. The Mangroves have responded to the aeration of the soil, rendered possible through the damming back of the tide, by dispensing with their pneumatophores, a few only of the breathing roots remaining, in a debilitated condition, at the base of their trunks. The sweetening of the soil has encouraged the invasion of the Mangroves by a grass and ruderal pasture (Plate xxvi., fig. 20).

The Mangrove is dependent on currents for distribution, a mode of conveyance for which it is admirably equipped, the fruit, with the seed in a more or less advanced stage of germination, falling within the range of tidal movement which promotes its dispersal. When deposited on a mudbank the fleshy cotyledons swell rapidly and rupture the leathery pericarp which is then discarded, the roots simultaneously sprouting from the quickly elongating hypocotyl and securing the young seedling in position. The advanced stage of vivipary (40, p. 236) and the extensive flotation of the seedlings (13, p. 76) attributed to tropical members of the genus, do not occur in the local marshes. In the Port Jackson district, *Avicennia officinalis* flowers in June and its fallen fruits were seen in profusion on the mud-flats in December.

The Mangrove formation is surrounded on the landward side by a carpet of *Salicornia* which extends to the dry salt plain. Of certain Molluscs found in the local marshes Hedley (18, p. 46) writes:—"These range from the fringe of glass wort, locally called 'samphire,' *Salicornia australis*, along the high-tide mark downwards as far as the *Avicennia* grows." The association of Mangrove and *Salicornia* is of frequent occurrence throughout their geographical range, each occupying relatively similar positions on the marsh.

The adaptable *Salicornias* are represented in all climatic zones, but the Mangroves are largely restricted to tropical and subtropical regions, only the hardier species venturing into colder temperatures. Under normal conditions the boundaries of the *Salicornia* meadow and the *Avicennia* arboretum are strictly maintained, the dense thicket of pneumatophores presenting a formidable barrier to intruders. On the banks of Duck River, a few hundred yards below the dam separating the fresh and

tidal waters at Clyde, a belt of Mangroves is bordered by a sward of *Salicornia*, the line of demarcation between the formations showing a cleavage as sharply defined as the verge of an artificial lawn bordering a footpath. The invasion of the Mangrove forest is initiated on its landward boundary, where the uplift of the marsh by the accumulated debris has stabilised the muddy surface and created a situation favourable to the *Salicornia*. Isolated plants of the latter, and its occasional rival but more frequent ally, *Suaeda maritima*, evade the defending pneumatophores and gain a precarious foothold among the dwarfed shrubby Mangroves on the fringe of the forest. Their presence assists the factors already operating to render the position untenable to the Mangroves and, as they retreat, the *Salicornia* which in this station outstrips its shorter-lived associate, occupies the vacated area. At the head of Iron Cove, the formation of a road through the marsh has made a clearing in the Mangrove forest, and the first to enter the breach were the *Salicornia* and *Suaeda*. A similar occurrence was noted at Homebush Bay, a third herb, *Atriplex patula*, also obtaining a footing in the broken Mangrove formation.

Near the mouth of Cook's River a group of Mangroves has been felled and the area is overrun by *Salicornia*. Several young Mangroves have sprung up, but are unable to attain an arboreal development, the close carpet of *Salicornia*, favoured by the collection of soil and detritus, placing them at a disadvantage. On an open reach of the Parramatta River at Meadowbank, the *Salicornia* exhibits antipathy for a sandy habitat, its formation breaking up while in transit from the marsh mud to the sandy shore upon which its further progress is arrested.

On the tide-flooded plain the *Salicornia* is an almost pure culture with a remarkably even compact carpet rarely exceeding a few inches in height, the stems developing the short internodal growth attributed by most writers to the effects of intense insolation. Where it ascends the drainage channels, it is frequently built up, in shoal water, into hummocky patches, the stems attaining a length of  $1\frac{1}{2}$ —2 feet. On the marsh plain, individual plants are usually arranged in spreading radial tufts, the closely-knitted, shortly-rhizomatic, procumbent stems buried under the silt to a depth equal to the emerged portion. As the stem disappears beneath the soil it loses its succulence and develops a tough wiry rhizome, which produces adventitious roots plenti-

fully supplied with root hairs, an exceptional provision in the saltmarsh plants.

The faculty of excreting hygroscopic salts by means of salt glands is ascribed to certain saltmarsh and desert plants by various investigators who are not, however, in agreement as to the role of this function. A theory which finds some acceptance is, that the excreted salt crystals absorb water from the atmosphere and deliquesce, the plant absorbing the moisture through stem or leaves. It has also been maintained that the plant is merely ridding itself of an accumulation of injurious salts.

When drying specimens of *S. australis* for mounting, the writer observed that salt crystals, formed in the stems, had ruptured the epidermis in several places, and were protruding through the apertures. The turgidity of the *Salicornia* varies with the salt content of the soil, numerous experiments showing that the plants lose much of their succulence when grown in ordinary garden soil. The halophytic tendency of the genus is exemplified by its world-wide distribution in saline stations. Of the 9 species of Australian *Salicornia* 7 are shrubby; 1 is an annual, and 1 a perennial herb; 5 are exclusively interior species and 3, including *S. australis*, are coastal; 1 species, *S. arbuscula* R. Br., is coastal in Victoria, and an interior species in New South Wales. The *Salicornia* is distributed by currents; the fruiting spikes fall at maturity with the seeds *in situ* and float away on the tide. (This character is not so well developed in *S. australis* as in some other members of the genus.) Discussing the dispersal of *S. australis*, Miss Cooke (4, p. 361) says, "When the seed is ripe the fleshy perianth persists, the cell-contents disappear, and the cell-walls become thickened by regular bands which run in different directions in different cells, and the cells are filled with air. This is evidently an adaptation for dispersal; for by means of this persistent perianth the seeds float on the top of the water for a long time. Seeds were placed in fresh water, and at the end of a week only 3 per cent. of them had sunk." [Seeds of this species with the perianth removed sank in a few hours in fresh water.—A. A. H.] Guppy (13, p. 545) notes that the seeds of *S. herbacea* germinate in sea water more readily than fresh, and the sea water seedling is much the more vigorous and healthy of the two; he remarks: "The floating seedlings can evidently disperse the species."

The Sea-blite, *Suaeda maritima*, a cosmopolitan species and a member of the same family as the *Salicornia*, (Chenopodiaceæ), is usually associated with the latter either as a competitor—in the tidal zone—or as a colleague in the work of clothing the intermediate barren plain. In the tide-flooded area, the somewhat woody stem of the Seablite is early decumbent and reclines on the soft mud, producing an abundance of lateral adventitious roots which spread horizontally on the surface of the slimy ooze (Plate xxvii., fig. 22). The extremity of the stem is curved upwards and plentifully furnished with divaricate branches thickly clothed with succulent, semi-terete leaves. The ramification of the interlaced branches with their heavy canopy of foliage, in combination with the close network of surface-spreading, matted roots, constitutes its defensive system. In the numerous conflicts in which the Seablite and the *Salicornia* are engaged, the latter generally emerges victorious, its vegetative reproductive system and perennial growth enabling it to overcome its shorter-lived opponent, which is entirely dependent upon sexual reproduction for colonisation. Seedlings of the *Salicornia* attempting to obtain a footing in the Seablite formation are promptly suppressed by their taller antagonist, which deprives them of the necessary light by interposing its leafy curtain, and prevents their lateral growth by the density of its own superficial root system. Invasion of the *Salicornia* by the Seablite is equally futile, seedlings of the latter obtaining a temporary footing in the *Salicornia* carpet finding it too compact to penetrate, the inability of the adventitious roots to reach the surface of the marsh resulting in the collapse of the intruders. The frequent breaches in the *Salicornia* carpet, due to unfavourable conditions arising in the habitat, afford the Seablite numerous opportunities for encroachment. Its quickly germinating seeds, of which large quantities are shed in contiguity to the *Salicornia*, are swept by the wash of the tide into the denuded gap, which is invested with a sturdy growth of the Seablite before its slower moving antagonist is able to enter the breach. When the latter arrives at the margin of the Seablite formation, its wiry rhizomes are insinuated under the shallower root system of its opponent, and, as the shorter-lived Seablite disintegrates, the rhizomes of the *Salicornia*, rising obliquely, occupy the ground before a new crop of Seablite seedlings can secure a footing. The invasion continues until the Seablite is either

driven out or a change in the conditions again weakens the *Salicornia*, and permits its opponent to reassert a temporary supremacy. A typical example of this intrusion was noted at Hen and Chickens Bay, where the *Salicornia* carpet surrounding the Mangroves is exceptionally compact. Near the boundary of St. Luke's Park, a weak salient in the *Salicornia* has been occupied by the Seablite, which has entered its carpet in a wedge-shaped formation, whose apex has reached the Mangroves, completely bisecting the *Salicornia* sward. The boundary of the joint formations on the northern side runs along the fence of the Rifle Butts with a well-defined line of demarcation, the intrusive Seablite, pallid, and taller than its rival, attracting the attention of the observer from the marsh bank. At Homebush Bay a dyke has been thrown up along the bank of the tidal channel running through the centre of the marsh to protect the plain from floods. The Seablite has taken advantage of the resultant alteration in the habitat and obtained possession of the station on the banks of the tidal channel intermediate between the dyke and the Mangroves, fringing them with a narrow border (Plate xxii., fig. 11). In the artificial habitat created by the stoppage of the tide flow, the Seablite has its opponent at a disadvantage, as the *Salicornia* is unable, under the supervening dry conditions, to construct a carpet, its formation breaking up into small patches or individual tufts. The narrow margin of superiority held by the *Salicornia* over the Seablite is well demonstrated on the broad expanse of plain affected, where neither species is capable of maintaining a massed carpet, both breaking up into small patches or individual tufts and frequently intermingling (Plate xxiii., fig. 13), the *Salicornia* by virtue of its perennial habit eventually supplying the major portion of the plain vegetation. On a section of the marsh at a point opposite the Concord West railway station, the plain is traversed by two almost parallel branches of the central tidal channel, which extend for a considerable distance in the direction of the marsh bank enclosing a strip some 30ft. wide. The banks of the shallow waterways are lined with Mangroves which display a graduated reduction in development as the channels merge into the plain, the attenuated bushes at the extremities, where the tide flow ceases, limiting their foliage to a few scattered leaves (Plate xxii., fig. 12). This natural avenue lends a unique feature to the landscape, the enclosed space, which is slightly raised above the level of the plain, carry-

ing an almost pure sward of Seablite which conveys the impression of a strip of lawn enclosed by hedges.

On the drier parts of the plain the Seablite gradually loses its decumbent habit and discards its lateral surface roots. A similar alteration in the habit of the northern *Suaeda fruticosa* growing on a shingle beach is noted by Oliver and Salisbury (31, p. 260). The Seablite was not observed by the writer on the ocean shore-line, but Bentham\* notes it as abundant on shingle beaches close to high water mark in Tasmania.

The formation of salt crystals in the stems and their extrusion from the epidermis as in *Salicornia*, was also noted in dried specimens of the Seablite.

In typical local estuarine bays the tide-flooded area on the littoral boundary extends to the marsh banks, a series of irregular formations, chiefly low, carpet-forming succulents, occupying the space between the *Salicornia* and the reeds. In this station the former is intruded by occasional patches of *Wilsonia Backhousii* Hook. f., a creeping, stoloniferous perennial with a flat carpet. There are three species of *Wilsonia*, none of which is admitted by Bentham into the flora of New South Wales,† but they are all recorded in local publications, and there are specimens in the National Herbarium of *W. rotundifolia* Hook. from Lake Cudgellico and Lake Bathurst, and of *W. Backhousii* from the local marshes. The genus is endemic in the Commonwealth, New South Wales and Tasmania representing respectively its northern and southern limits.

Where the tidal detritus has extended the base of the bank into a terrace, the *Wilsonia* creeps over it, consolidating the drift, its compact formation of crass fleshy leaves, closely appressed to the soil, narrowing with the deposit into a band, or, where the bank rises abruptly from the marsh, into a mere fringe. At Homebush Bay, a *Wilsonia* formation an acre or more in extent was noted on a comparatively dry peaty stretch of the salt-plain, where, under the drier conditions and loose soil, it is unable to maintain a continuous carpet, breaking up into small mats or stools. The *Wilsonia* is essentially halophytic and does not extend to the fluvial zone. The genus is a degenerate offshoot of the *Convolvulaceae*, a family largely constituted of climbers

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\* Flora Austr., v., p. 206.

† Flora Austr., iv., 439.

with showy trumpet-like flowers, e.g., the "Morning Glory," *Ipomoea purpurea* Roth. The inadaptability of the *Wilsonia* for dispersal is accountable for its limited range, neither the small fruited capsules, nor their seed contents possessing an equipment for lengthy flotation.

*Mesembryanthemum tegens* F. v. M., which is also a creeping succulent perennial with the trigonus leaves common in the genus, was noted at Homebush Bay and other saltmarshes in the vicinity in the same zone as the *Wilsonia*. This plant was described\* from specimens growing in a similar habitat in Victoria, "In pratis depressis paulo salinis urbi Melbourne adjacentibus," where it is probably endemic. It forms a compact carpet, studded with a profusion of bright rose-pink flowers, and is commonly grown as an ornamental garden plant, the name figuring in the catalogue of plants growing in the Sydney Botanic Gardens, published in 1895 (p. 42). The grounds of Miss Eadith Walker at Yaralla and those of the Walker Hospital are probable sources from which the plants may have been disseminated, as the boundaries of both establishments extend to the neighbouring saltmarshes. The carpets of *Mesembryanthemum* and *Wilsonia* are for the greater part distinct, each clothing a section of the marsh bank, or a flattened ridge among the shallow water channels, but in places they run in parallel lines along the bank, the *Wilsonia* occupying the inner—more frequently flooded—zone. Their growth is usually complementary, their root systems ramifying in different directions, the roots of the *Wilsonia* descending to a greater depth than those of its associate. The root system of the *Wilsonia* is rhizomatic, *Mesembryanthemum*, which is a surface creeper, emitting tufts of vertical roots from the nodes. When growing side by side, an occasional rampant runner from the *Mesembryanthemum* overlaps and, finding an opening in its neighbour's carpet, promptly descends and roots, eventually—where favoured by the habitat—overrunning the plants in its vicinity and establishing a patch in the invaded territory. A sandy soil is favourable to the *Mesembryanthemum*, the *Wilsonia* displaying a preference for the black mud of the marsh. It is remarkable that *M. tegens* is not more widely dispersed, as the crustaceous coat of the seeds is sufficiently protective to preserve their germinative power

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\* Phrag. Phyto. Austr., v., 157.

when eaten by birds. The small seeds, which are freed from the capsule (dehiscent) when ripe, sink almost immediately when immersed in water.

*Selliera radicans*, another perennial carpet-forming species, is occasionally present in the tide-flooded zone, the largest local formation noted extending along the marsh margin at Iron Cove. This formation stretches for a considerable distance in a broad band, occasionally interrupted by unfavourable edaphic intrusions. On the saline mud at the base of the marsh bank its heavy succulent leaves are closely appressed to the ground, overlapping in several layers, the resultant carpet presenting a dense barrier to encroachment by the surrounding herbage. On the landward boundary, the *Selliera* has attempted the ascent of the sloping bank, but the Salt-grass, *Sporobolus virginicus* Humb. & Kunth., which is firmly established in this station, has obstructed its passage, its strong, wiry framework forcing the soft fleshy stems of the *Selliera* to rise obliquely from the ground. When the stems of the *Selliera* lose their grip on the surface they trail over the Saltgrass sward, and as they are unable to again descend to root their further progress is arrested.

On the muddy flat the struggle for existence in the *Selliera* carpet is very severe and has resulted in the production of short crass leaves, sessile and crowded. The harsh conditions are also responsible for a prolific growth of flowers, which are closely appressed to the stems and almost cover the surface of this section of the carpet. The flaccid aerial stems trailing over the salt-grass are not subject to this competition and have responded by the adoption of a lax growth habit, broadening the leaf blades and raising them on stalks, reducing their turgid succulence, and spacing them distantly along the branches (Plate xxix. fig. 25). A further response to the removal of the stress of competition is the cessation of sexual reproduction, the well-favoured stems either declining to produce flowers or reducing the output to a negligible quantity. In the muddy station the *Selliera* meets outlying tufts, or occasional patches, of *Juncus maritimus* var., and surrounds them, closely investing the spaces between the tufts. The association of *Selliera* and *Juncus* is noted by Guppy (13) among coast plants in Southern Chile.

The fruit, which is slightly succulent, retains the seeds when it falls (indehiscent), but its weakly constructed walls are readily permeable and soon collapse in water, releasing the seeds.



Dried capsules floated for a week, a thin glutinous coating keeping them dry for several days. Of a number of seeds tested the majority sank in a few hours, none remaining afloat 24 hours. The seeds are compressed and when young are encircled by a membranous wing which is extremely fugacious, the mature seeds rarely retaining more than a ragged fringe on their border. The fugitive nature of the wing renders it valueless for flight, and the flat, creeping growth-form of the plant, and its customary domicile, are also opposed to this means of dispersal. This species has been omitted by Bentham from the flora of New South Wales,\* though it is very common in our local salt-marshes.

*Samolus repens*, a slender floriferous perennial which extends to New Zealand and New Caledonia, finds a refuge in depressions in this zone which are too frequently submerged to permit of their occupation by the *Selliera* and other carpet-forming species. It spreads superficially by means of runners which root at intervals and produce tufts of short stems, its rhizomatic system connecting the mature clumps subterraneously. The small plants are somewhat frutescent and have thin, hard (sclerophyllous) leaves, lustrous on the upper surface, an unusual occurrence in this station. The extensive ramification of its root system is a valuable provision for securing an anchorage in the mobile mud. The *Samolus*, though exceptionally well equipped for such a habitat, is a fugitive in this station and is only permitted to occupy the spaces edaphically repugnant to the surrounding succulents. The largest colonies of this species noted were established in a *Salicornia* meadow at Buffalo Creek on the Lane Cove River.

On the ocean headlands it is frequently associated with *Lobelia anceps* clothing a rock ledge or invading a crevice, their weak straggling stems, drawn and flaccid, appressed against the face of the cliff, seeking shelter and support. The *Lobelia* is also occasional in the saltmarsh but is unable to tolerate the harsh conditions obtaining in the station occupied by its confrere, and cannot advance further than the detritus heaps on the plain, its frequent presence and sturdy growth in freshwater swamps indicating the excessive soil salinity as the deterrent factor. The *Samolus* is more partial to a muddy than a sandy soil and can-

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\* Flora Austr., iv., p. 82.

not ascend the dry marsh banks. Its numerous small seeds only float for a few hours, the protective crustaceous seed-coat pointing to its dispersal by birds.

The outermost series in the zonal succession on the flooded marsh littoral is a *Juncus* association, which introduces a taller type of vegetation with a cylindrical growth form. The stems of these rushes are strongly built, the epidermis forming a cylinder of bast, highly cutinised, and the walls of the air cavities are arranged in a stout network binding the frame both longitudinally and transversely. The lacunar tissue so well developed in the *Juncus* is disadvantageous, as it increases transpiration, but offers a modicum of compensation by storing a supply of oxygen and lightening the stem structure. The firm texture of the rushes enables them to advance into the weaker formations of the succulents in their vicinity, wherever a change in the edaphic conditions favours a forward movement.

The dominant species in the local marshes is *Juncus maritimus* Lam. var. *australiensis* Buchen., a tufted, shortly rhizomatic herb. Its supremacy in this zone is rarely challenged, though a Cyperaceous rush, *Cladium junceum*, R. Br., which extends from Queensland south to New Zealand is an occasional competitor in stations where the saline conditions operate in its favour. At Buffalo Creek on the Lane Cove River, near the bisection of the marsh by the Pittwater Road, the *Cladium* and *Juncus* run side by side along the marsh margin in parallel bands (Plate xvii., fig. 2). At intervals the drainage, collected into short gullies, enters the marsh, forming shallow bays on its margin. The soil salinity in the bays is considerably reduced, the dilution of the marsh water acting unfavourably upon the *Juncus* formation. The more plastic *Cladium*, preferably a lacustrine habitue, is not prejudicially affected by the influx of fresh water and in these stations advances into the *Juncus* formation, occasionally pressing through its ranks and occupying a frontal position (Plate xviii., fig. 4). An extensive formation of *Cladium junceum* was noted on the margin of a lake in the Centennial Park. In this habitat the conditions which confine it to a narrow band on the marsh margin or the bank of a tidal stream, *i.e.*, the severe competition of the *Juncus* on its aquatic boundary, and the abrupt transition to a dry station on the landward bank, are absent, and the *Cladium* spreads from the shallow waters of the lake, in an irregular formation, into the adjoining

swamp, its movements limited only by the degree of soil saturation. The regularity of the zonation of these frequently associated rushes is exemplified on the banks of George's River, at Como, where their several ranks extend in parallel lines forming an even band, 6-8 feet wide, for a distance of several hundred yards, the *Juncus* keeping the front line along the river margin. The slightly reduced height of the *Cladium*, its pale green stems, and insignificant inflorescence are sufficiently distinctive to enable the observer to follow the lines of their respective boundaries throughout their association. The fruits of *Cladium junceum* have no flotation, seeds 5 years old, which resemble a leaden pellet in size and colour, sinking at once.

In a shallow basin on a saltmarsh at Clyde, the cosmopolitan Reed-mace, *Typha unguistifolia* L., has established a colony, an irregular formation of *Juncus maritimus* occupying a position on the border of the depression, a vacant space several yards wide dividing them. The factor limiting the boundaries of their respective formations is the decreased salinity of the water in the basin, which is fed by a sluggish seepage from the marsh bank, rendering it prohibitive to the *Juncus*, though congenial to the Reed-mace, the ridge on the border of the basin remaining inaccessible to either. The ovaries of the flowers of the Reed-mace are surrounded by tufts of hairs affixed to the stipes which fall off with the fruit, simulating the pappus of a Composite.

The saltmarsh at the head of Woolooware Bay, Cronulla, is merged into a swamp in which tidal and fluvial waters intermingle. A forest of *Casuarina glauca* has spread over the swampy area from the verge of the tidal zone to the dry landward slopes. In this station *Juncus maritimus* has relinquished its banded formation and, adopting a massed disposition, has invaded the forest to the boundary of the fluvial zone. Its frequent associate, *Cladium junceum*, is also represented by a series of diffused patches, and two reed-like Sedges. *Scirpus littoralis* Schrad., a species common in the Mediterranean, which is tolerant of a lacustrine habitat, though much better developed under estuarine conditions, and *Cyperus laevigatus* L., common in most warm regions, noted only by the writer in estuarine stations, have also established small colonies in the *Juncus* formation. The seeds of these two Sedges have a brief flotation, dried seeds of both species sinking within 24 hours. Discussing New Zealand halophytes, Miss Cross (7, p. 547) remarks:—

"In the neighbourhood of one lagoon . . . only one small tuft of *J. maritimus* was collected. This, perhaps, may be accounted for by the fact that there are no mud-flats, the soil being of a rather sandy nature." The choice of a muddy rather than a sandy station is characteristic of this *Juncus* in the Port Jackson district also.

At Cook's River *Juncus pallidus* R. Br., a species endemic within the Commonwealth, has established its tufts—slightly taller and stouter—among those of *J. maritimus* var., on the drier parts of the marsh plain, but its dominance on the margin of a slightly brackish pool—a station into which *J. maritimus* cannot enter—demonstrates its preference for the less saline habitat. *J. maritimus* extends from the tide-flooded zone to the boundary of the fluvial station, invading the plain *en route* where the soil is sufficiently saturated to permit its growth, *Cladium junceum* declining to accompany it beyond the tidal zone. In its passage across the salt plain, *J. maritimus* has again discarded its banded formation, the dry conditions causing it to separate into small patches or isolated tufts. [At Swansea, Lake Macquarie, hundreds of acres of the marshes are covered with a lax growth of this rush, the individual tufts remaining sufficiently distinct to be non-competitive.] The sequence of the rushes in the ascent of the marsh banks is continued by *J. effusus* L., a cosmopolitan species, and followed on a higher level by the Australian *J. polyanthemus*, a slender stemmed form separated from *J. effusus* by Fr. Buchenau. Of the seeds of *J. maritimus* var., *J. pallidus*, *J. effusus*, and *J. polyanthemus*, none have more than 24 hours' flotation. The seeds of each of these species emitted a slight coating of mucus when immersed. The position on the margin of the marsh plain, which, owing to its infrequent submergence has become prohibitive to *Cladium junceum*, is occupied by the Salt-grass, *Sporobolus virginicus* Humb. & Kunth., a creeping perennial represented in most warm regions, which develops a lax growth, 1-3 inches high, on the verge of the plain, its sward rising and becoming more compact and rigid as it extends inland. In occasional depressions where seepage from the marsh banks has collected, the Coast Couch, *Zoysia pungens* Willd., also a salt-loving grass, but less halophytic than the Salt-grass, forms irregular patches in the sward of the latter, but on the saline plain ranges behind it in interrupted bands. The *Zoysia* is also of perennial duration and

very similar in structure and habit of growth to its associate—both have the convolute leaves of the xerophyte, and a spike-like inflorescence—and their boundaries, though usually very decided, are not readily discernible, especially when they are not in flower, the height of the *Sporobolus* sward where the formations meet approximating that of the *Zoysia* and accentuating the homoplasy. The two grasses are frequently associated both in the saltmarsh and on the seashore, occupying relatively similar positions in either station, the *Zoysia* forming the larger colony on the dune and the *Sporobolus* dominant in the marsh.

In their coastal traverse the *Zoysia* is frequently found intruding a lawn of Common Couch, *Cynodon dactylon* Rich., several miles inland, but the *Sporobolus* rarely leaves the vicinity of tidal waters. The *Zoysia* ranges from the maritime sands of Eastern Asia to New Zealand, where according to Cheeseman\* it ascends to 2000ft. at Lake Taupo and in Canterbury and Otago. The *Sporobolus*, which is common in saltmarshes in the interior, reaches its optimum growth in the local marshes on the infrequently tide-flooded plain, slightly uplifted, and with a fresh water seepage reducing the soil salinity (Plate xix., fig. 5). The small, hard, mature grains of the *Sporobolus* are naked when ejected from the glumes and hang for some time on the outside of the spikelets before falling.

## 2. The Dry Salt Plain.

The stretch of dry salt plain extending from the tide-flooded area to the fluvial zone is for the greater part bare, the detritus heaps and ridges usually formed round the decaying stumps and roots of the dead Mangroves or other obstructions, and the pools, channels, and moist depressions, harbouring a few hardy pioneers, chiefly fugitives from the adjoining formations, which eventually prepare the habitat for the advent of the fluvial vegetation. The detritus heaps are frequently coated with a sward of *Sporobolus virginicus* and outlined with an edging of *Salicornia*, the latter seated on the plain (Plate xx., fig. 8). The severity of the conditions prevailing in this station is exemplified by the efforts of the *Sporobolus* to invade the salt plain. An outlying stem from the sward creeps down the side of the mound and pushes out on to the bare plain. Flattened and closely appressed to the surface, it proceeds for a short distance when its

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\* Manual Fl. N.Z., p. 844.

progress is arrested and it sickens, turns black, and dies. On the demise of the premier shoot, a series of laterals issues from the inner joints and advances *en masse*, but is compelled to either turn aside or meet the fate of the leader (Plate xix, fig. 6). The *Sporobolus* lawn on the detritus mounds provides a refuge for a series of miniature colonies, small groups of a species, or individual plants, chiefly ruderals of annual or biennial growth, and a root system usually vertical descending below that of the *Sporobolus*. The Orache, *Atriplex patula* L., a weedy annual introduced from Europe, is occasional on these mounds though the bulk of its herbage is disposed in the vacant spaces of the Seablite-*Salicornia* formations, isolated plants occasionally reaching the verge of the Mangroves. In areas where the conditions are exceptionally favourable it frequently grows in dense patches, reaching a height of 3 feet and temporarily excluding the lower growths by overshadowing them with its close fleshy foliage. A luxuriant growth of the Orache was noted on the marsh plain at Homebush Bay, and a ribbon-like colony was seen at Hen and Chickens Bay crowning a low bank on the margin of a drainage channel. The colony at Hen and Chickens Bay was interspersed, in December, with young plants of the New Zealand Spinach, *Tetragonia expansa* Murr. In the following June this locality was again visited and the *Atriplex* had ripened its fruits and was rapidly dying; the *Tetragonia*—also an annual—having developed the bulk of its heavy foliage, dominated the position. These plants were noted, in several of the estuaries visited, in mutual occupation of an area under a similar phenological arrangement. The invasion of the salt plain by the Orache is ephemeral, its brief existence passing and permitting the reappearance of the lowly marsh herbs. Its leaves are encrusted with an excretion of salt which, in addition to relieving the plants of an injurious deposit, affords the leaves a measure of protection from the intense insolation prevalent in this station. The Orache is widely distributed in temperate regions and owes its dispersal to the agency of both currents and birds. Guppy (13, p. 537) lists the fruits as floating for six months. [Seeds, released from the calyx in which they are enclosed and stripped of their membranous coat, sank at once.—A. A. H.] The capsules of the New Zealand Spinach floated for a week, the dried epicarp supporting the weight of the bony endocarp until saturated.

Two annual grasses, *Calamagrostis aemula* Steud., found in all the Australian States and New Zealand, and the curly, tufted *Lepturus incurvatus* Trin., common on the Mediterranean littoral and extending from India to Australia and New Zealand, are frequently present on the detritus mounds, and scattered generally throughout the various formations bordering the salt plain. The *Calamagrostis* is less halophytic than the *Lepturus*, extending to the fluvial formations and the moist meadow on the marsh slopes, and frequently occurs among the rushes and sedges in a freshwater swamp. Both grasses establish colonies in the formations of the permanent herbage, neither forming an independent sward; a few tufts occasionally occupy a vacancy in a suitable habitat. Their vertical roots do not compete with the horizontal root systems of the grasses or other herbs with which they are usually associated. The *Lepturus* frequently forms extensive banded colonies in a sward of *Sporobolus*, *Zoysia*, or *Cynodon* on the marsh margin, completing its life cycle before the demand for space created by the spring activities of its hosts becomes insistent, the disintegration of its colony providing a mulch of humus for the permanent pasture which has given it sanctuary. It is rarely taller than the herbage with which it consorts and has to contend for aerial space and access to the light. To obviate the danger of being overrun, the outer stems of the *Lepturus* tufts curve laterally from the base, pressing back the more yielding superstructure of its associates and securing space for expansion and admission of the essential illumination. The fruits of the *Lepturus* are embedded in cavities in the rachis of the flower spike and the joints, which separate at maturity, are floated by the tide into the surrounding formations.

The *Calamagrostis*, which rarely assembles in large patches, has a weak growth and is unable to spread among its associates. The plants are compressed, their soft basal leaves yielding to the pressure of the surrounding herbage, folding vertically around the stem, and threading their way through the interstices to the light. The stem rises above the sward to mature its plumed floral panicle which bends when weighted with grain, resting on the sward. Finally, the fruit-laden branches are snapped off by the wind and collected into a ball which is blown over the meadow or salt plain, scattering its seeds, simulating the Tumble Weed of the Western Plains. The broad soft leaves of the

*Calamagrostis* are aberrant in the saltmarsh, as they are essentially mesophytic, but the demand for moisture is more insistent than distaste for the salinity of the marsh or the acidity of the swamp.

The Spurrey, *Spergularia rubra* Camb., supports a fluctuating growth on the salt plain among the detritus heaps, occasionally forming a limited sward on the more habitable parts of the plain. This cosmopolitan species, a low procumbent succulent herb with varicolored flowers (red to white) of a dull hue, is of annual duration in cold regions but attains a biennial growth in our local marshes. It is joined in this station by a yellow Marsh Daisy, *Cotula coronopifolia* L., a shortly rhizomatic perennial with a wide range, chiefly maritime, in both the Old and New World, whose bright flowers are conspicuous among the dull surroundings. In the area in which they are associated, these herbs are not competitive, the conditions precluding a strong growth in either formation, and their diverse root systems seek nutrition at different levels. The *Cotula* does not venture as far on the dry plain as its associate, its larger and more luxuriant colony in the vicinity of the pools and soaks (Plate xxiv., fig 15) disclosing its partiality for moisture, and its more rank growth in the fluvial mud on the side of the drainage channel presents *prima facie* evidence of its inclination for a less saline habitat. The Spurrey requires less moisture and is more strictly halophytic. The *Cotula* was present in all the marshes visited, but the *Spergularia* was not so well represented, the stretches of salt plain at Cook's River in the neighbourhood of Tempe railway station carrying the largest colonies noted.

Guppy (13, p. 540) notes little or no floating capacity in the seeds of the maritime forms of *Spergularia rubra*, with or without winged seeds, even after prolonged drying. [Seeds of saltmarsh plants, one year old, tested by the writer, sank at once.]

During the testing of the buoyancy of the achenes of *Cotula coronopifolia*, a quantity of a gelatinous adherent mucus was emitted when the seeds were immersed. The presence of this species in extra tropical South America, New Zealand, and South Africa, and its capacity for dispersal by gulls and other sea-birds owing to the adherence of its sticky fruits to their feathers, gives it a measure of significance in relation to the Antarctic problem discussed by Guppy (15) and Hedley.\*

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\*The Palaeogeographic Relations of Antarctica.



The *Sporobolus* sward covering a typical detritus mound on the salt plain at Cook's River is intruded by a lax colony of *Lobelia anceps*, also an extratropical inhabitant of S. Africa, S. America, and New Zealand. It is a straggling perennial with succulent leaves and stems, and a shortly rhizomatic root system which finds ample room for development in the open network of the debilitated subterranean growth of the *Sporobolus*. On its margin, a congener, *L. debilis* L. f., a weak annual indigenous in South Africa, but an alien weed in most temperate countries, has established a compact colony in which the fraternal struggle for space is keenly contested. The individual plants which, under normal conditions are branched and spreading, are so closely packed that their stems are unbranched and leafless almost to the summit which is crowned with a short tuft of leaves. Both species have small flowers, those of *L. anceps* being light blue and of its congener a dull reddish colour. The small seeds of both species sank within 24 hours.

Several plants of *Cyperus polystachyus* Rottb., a perennial sedge confined to Australia, with a range from Port Jackson to Queensland, are scattered through the *Sporobolus* sward. In the flattened growth of *Sporobolus* on the detritus mounds, the *Cyperus* has space in which to develop, but in the erect swards of either *Sporobolus* or *Zoysia* on the marsh margin it is speedily suppressed, the taller grasses closing round the short, flaccid, basal leaves of the *Cyperus*, spreading over them, and depriving them of the light. This sedge occasionally occupies a narrow strip on the margin of the plain between the bands of reeds and the customary lawn on the marsh banks—a habitat too dry for the reeds and too salt for the grass. A ribbon-like colony of *C. polystachyus* was noted ranging behind a band of *Cladium junceum* in this exclusive station on the banks of George's River at Como.

A small scattered colony of *Plantago coronopus* L., the only rosette-forming species observed in the saltmarsh proper, occupied an elevated position on the mound. This *Plantago*, an annual in cold climates, is a biennial in the local marshes. It is common in most temperate countries in the northern hemisphere, chiefly maritime, and probably an introduction into Australia. This is the only station on the salt plain open to *P.*

*coronopus*, as it requires a permeable soil, usually frequenting a sandy habitat, and is intolerant of the salinity of the plain either in the dry or flooded areas.

Discussing the dispersal of seeds by Gulls, Guppy (15, p. 421) says: . . . "*Plantago coronopus*, which grows on the rock ledges where these birds nest. Here the seeds emit mucus and become sticky when wetted, and they would adhere firmly to a bird's plumage when dry." This species was noted by the writer growing on the rock ledges of the ocean escarpment at Coogee (17, p. 339).

One of the Cudweeds, *Gnaphalium purpureum* L., a cosmopolitan weed of annual growth was represented on the mounds in small patches. It is more frequent in a moist meadow or the sparse sward of an open forest (Savannah), its lax frame and flaccid mesophytic foliage indicating its anomalous position in the saltmarsh. The xerophytic equipment of the Cudweed consists of a coating of cottony hairs but this provision is insufficient for a prolonged resistance to the harsh conditions obtaining in this station, and it frequently collapses before it has reached the flowering stage. The distribution of this widespread herb, apart from man,—it is a horticultural and ruderal weed—is the work of birds. Though the minute achenes are crowned by a comparatively large parachute-like pappus, they are not wind dispersed, as the ring of hairs, united by their bases into a short tube, is detached at maturity and drifts away on the breeze, the small solid seeds falling in the vicinity of the parent plant. The membranous seed-coat would resist erosion when eaten by birds. The seeds have little flotation, sinking within 24 hours.

On the dry salt plain at the head of Homebush Bay, the slender *Apium leptophyllum* F. v. M., a succulent annual with finely dissected foliage, was sparsely represented among the salt-grasses. This weedy herb is indigenous in tropical Africa and America and has a coastal range throughout Eastern Australia. Though its presence in the saltmarsh and on the seaboard would denote a tolerance of saline conditions, it is not as exclusively halophytic as its coastal congener, *A. prostratum* Labill., which, however, does not favour the saltmarsh, owing to its objection to a sour and muddy soil. The structure of *A. leptophyllum* is largely xerophytic, but it is frequently located in a moist shady sward.

Several plants of the Half-berried Salt-bush, *Atriplex semi-baccata*, R. Br., a prostrate twiggy perennial with an extensive range, coastal and interior, within Australia—one of our best natural fodder plants—were also noted in this station. In common with most members of the family (*Chenopodiaceae*) it is a halophyte, but is apparently able to procure a sufficient quantity of salt from soils not classed as saline to satisfy its craving for this condiment. At Hen and Chickens Bay it has migrated a considerable distance across the dry plain, reaching the station occupied by its relative *Atriplex patula*.

Two alien Composites are established on the margin of the salt plain at Homebush Bay. The Bushy Starwort, *Aster subulatus* Mich., a tough-stemmed herbaceous perennial indigenous in the North American saltmarshes, has founded a colony among the broken *Salicornia* tufts, its tall dense growth excluding the surrounding herbage. Its confrere the Stinkwort, *Inula graveolens* Desf., a somewhat woody stemmed annual from the Mediterranean which has shown an extraordinary aptitude for aggressive colonisation in Australia, is unable to accompany the Starwort on to the salt plain, the soil salinity acting as a barrier to its progress. The parachute crowned fruits of the Starwort are held aloft on tall waving stems, the slender achenes are extremely light, and the pappus, which elings tenaciously, is relatively large, a series of factors favourable to wind transport. The fruits of both Composites sank within 24 hours, those of the Stinkwort emitting a slight mucus.

In the pools and shallow channels on the salt plain *Ruppia maritima* L., common in most temperate and subtropical regions, spreads a filamentous network, frequently occupying the whole of the space in which the water is sufficiently deep to permit the flotation of its thread-like stems. The occurrence of a *Ruppia* lagoon at Deewhy is noted by Hedley (18, p. 53) who presents a photo of the lagoon and offers some interesting observations on the range of heat and salinity imposed upon its occupants. The *Ruppia* prefers still water, usually occupying isolated pools and disconnected channels, but can withstand a moderate tidal invasion. [A series of *Salicornia*-encircled *Ruppia* pools occurs on the barren salt plain at Homebush Bay near Concord West railway station (Plate xx., fig. 7).] At Cook's River, near Tempe, a dense growth of *Ruppia* (Plate xxi., fig. 10) permeates the waters of a channel connected with

the river, bordering Unwin's Bridge Road. In exceptionally low tides the upper reaches of the channel are emptied and the *Ruppia* lies exposed on the mud (Plate xxi., fig. 9). The banks of the channel are lined on either side with a formation of *Triglochin striata* Ruiz. et Pav., a stoloniferous perennial with a wide extratropical range. The *Triglochin* is arranged in narrow bands at the mouth of the channel where the tide flow is strong and deep, broadening as the stream is ascended, the bands on either bank finally becoming confluent in the shallow headwaters. The zonal boundaries of the *Ruppia* and *Triglochin* are regulated by the facilities for submergence, the formation of the latter projecting at intervals into the stream, indicating, beacon-like, the shoals of the channel.

The Thatch-reed, *Phragmites communis* Trin., a cosmopolitan cane-like grass with an elastic growth form, has established a reed-bed in the saltmarsh on the banks of Cook's River at Undercliffe. The section of the marsh selected by the Thatch-reed receives a slight influx of drainage from the surrounding hills, and in this station the formation—a pure culture—reaches its optimum. In the tidal river it is restricted to a narrow band along the bank, rarely descending into water more than 2--3 feet in depth. Of this species Warming (40, p. 189) writes:—"It can grow in water 3 metres in depth." As shown above the Thatch-reed does not invade tidal waters in the Port Jackson district to the depth noted by Warming.

In an article on the mitigation of floods by forestry operations J. H. Maiden (29, vi., 1917, p. 130) recommends *Phragmites communis* as a useful grass for the protection of river banks from erosion. A small patch of the *Phragmites* detached from the reed-bed at Undercliffe, lying between the banks of the river and the dry salt plain which is not affected by the fresh water drainage, has developed a weak open growth into which a formation of *Triglochin striata* has intruded, filling the spaces between the thinly-ranked stems of the Thatch-reed with a compact sward (Plate xxv., fig. 18).\* Owing to the greater depth of the rhizomes of the Thatch-reed their formations are noncompetitive, and, sheltered and stayed by the stout culms of its tall associate, *Triglochin striata*—more tolerant of salinity than the *Phragmites*—here attains its full stature, 1-1½

\* This photo was taken in August when the haulm-leaves of the *Phragmites* were withered.

feet. On the dry salt plain, the *Triglochin* cannot maintain a connected sward, breaking up into small mats or isolated tufts which reach maturity and produce flowers and fruits when but 1-2 inches high (Plate xxviii., fig. 23).

On the opposite side of the river the scour sets in the direction of the bank which is deeply eroded. A long strip of Thatch-reed is here bisected by a band of *Scirpus littoralis*, each species maintaining in a large measure the integrity of its formation, an occasional rhizome of either species intruding its neighbour's colony and signifying its presence by raising a solitary stem (Plate xxv., fig. 17). The struggle for supremacy between the reed formations in this station is exceptionally severe, as their root systems descend to an equal depth and compete for sustenance and space on the same plane. The Thatch-reed maintains a large aerial growth, its tall culms carrying a quantity of broad flag which places it at a disadvantage with its competitor, whose narrow cylindrical leaves do not make a heavy demand on the roots for support, but the compact rhizomatic system of the Thatch-reed enables it to keep its more straggling opponent at bay. In the deeper water the Thatch-reed is reproduced vegetatively, but the plants growing in the shallow marsh mud frequently flower and fruit.

*Triglochin procera* R. Br., a flaccid-leaved, tuberous-rooted, aquatic herb, endemic within the Commonwealth, occasionally intrudes the open spaces of the formations of both Thatch-reed and *Scirpus*, occupying in the deeper water a position similar to that held by its smaller relative *T. striata* in the shallower habitat on the marsh. *T. procera* is not as communal as its congener and is one of the few perennial herbs frequenting the estuary which has not connected its members either epigeally or hypogaeally by means of runners or rhizomes. The fruits of *T. procera* have a brief flotation, the soft corky coat of the carpels, though buoyant, is soon saturated, none floating longer than 48 hours; the cylindrical seeds stripped of the coat sink immediately.

In a narrow tidal channel on the southern bank of Cook's River which enters the marsh on the eastern side of Cook's River Road, a ribbonlike formation of *Azolla filiculoides* Lam., var. *rubra* Diels., was observed lining the muddy bank on either side of the watercourse at high water mark. When visited in November (it is an æstival monocarp) the plants were resting

on the mud but would be awash at high tide. The *Azolla* is usually found in fresh water pools and was not noted elsewhere in the Port Jackson district in a saline habitat. Though the plants were vigorous, they had not collected into the close layer which they form in a pool, the thinness of the sheet reflecting the disturbing tidal influence. The diminutive fern-like plants float on the surface and are dispersed by currents.

### 3. *The Fluvial Zone.*

The line of demarcation between the dry salt plain and the fluvial zone is frequently indicated in the local marshes by the Swamp-Oak, *Casuarina glauca* Sieb., which follows the boundary of the plain in belted formation or spreads into an irregular forest in the fluvial swamp frequently formed at the head of the bay, or on the swampy river flats. Its movements are restricted to the vicinity of the tidal waters owing to its partiality for a saline environment and its objection to a dry station. In exceptional cases a grove of these trees has ascended the hillside to a distance of 1000 yards from the waters of the estuary, e.g., the clump near the Mitchell Library, and a straggling colony which has reached the Pittwater road at Deewhy. A forest formation of *Casuarina glauca* on the Parramatta River is depicted in a photo by R. H. Cambage.\* Belts of these pine-like trees line the banks of the Curl Curl lagoon on the Manly-Narrabeen Road and ornament long stretches of the banks of Cook's River at Undercliffe and Duck River at Clyde with shady avenues. The *Casuarina* is exceptionally well equipped to withstand the xerophytic conditions obtaining in the estuary, its vertically held cylindrical branchlets, arranged in switch-like tufts and practically aphyllous, offering a minimum surface for subjection to direct insolation.

The equisetoid branchlets are laxly jointed, and consequent upon the advent of a sudden dessicating factor such as the passage of a hot wind over the forest, they are easily dismembered and fall (simulating the leaf-fall of a mesophytic tree under a like provocation), affording the root system a speedy measure of relief from the strain of the accelerated evaporation.

The bedding of fallen branchlets under the trees has been compared by several writers to the carpet of Pine-needles in a

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\* in Maiden, J. H., *The Forest Flora of N.S.W.*, ii., 1907, p. 96.

Pine-forest. In a *Casuarina* forest at Bray's Bay on the Parramatta River, a carpet of branchlets was found several inches thick, which had rendered the habitat almost untenable for herbaceous vegetation. A sward of Salt-grass established on the verge of the salt-plain had forced a passage some yards into the forest by mechanical pressure, where the deposit was thin, but its further progress was arrested by the accumulation of dead branchlets. A few tufts of *Juncus maritimus* which had entered the forest were able to develop in its precincts, their strong, sharp-pointed leaves and stems pushing upwards through the debris to secure the necessary illumination. The cylindrical elongated branches of the *Casuarina*, held vertically and regularly-spaced, break the light in a manner suited to the requirements of the numerous epiphytes to which its protection is extended. On the banks of Tuggerah Lakes and the tidal channel entering the Tom Thumb lagoon near Wollongong, the trunks of the *Casuarinas* harbour dense masses of the Pencil Orchid, *Dendrobium teretifolium* R. Br., in addition to the Lichens which are invariably present. These trees are also exceptionally subject to infestation by parasitic *Loranthus* which frequently reward their host by accomplishing its destruction. It is doubtless more than a coincidence that the leaves of the Pencil-Orchid, and its associate *Loranthus linophyllus* Fenzl., (probably the var. *b.* of Bentham\* which has a coastal range from Brisbane to the Illawarra), both of which have chosen *C. glauca* as a host, should simulate the cylindrical growth form of its branchlets.

The seed-like nutlets of the Swamp-Oak are surmounted by a membranous wing and have a highly polished coat. The wing is larger than the nut and would carry it a short distance from the parent plant in a strong breeze, but is not adapted for a lengthy flight. The nutlets of *C. glauca* floated for a week, the varnished coat, though not ruptured, developing permeability at an early stage of immersion. Nutlets of *Casuarina distyla* Vent., which is not a halophytic species, sank within 48 hours. The influence of the wing on buoyancy is inconsequential, fruits from which the wings had been removed sinking in a like period to those upon which it was retained, though it was noted that the nutlets of *C. glauca* floated wing upwards, and those of *C. distyla* with the wing downwards.

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\* Flora Austr., iii., 394.

Several Tea-trees, *Melaleucas*, all of which are confined to Australia, constitute the major portion of the ligneous vegetation in the *Casuarina* forest (Plate xxvi., fig. 19). They have xerophytic leaves ranging from the prickly foliage of *M. nodosa* Sm., the less harsh and smaller cylindrical leaves of *M. ericifolia* Sm., the broader and frequently twisted leaf blade of *M. styphelioides* Sm., to the somewhat flattened elongated leaves of *M. linariifolia* Sm. *M. ericifolia*, a shrub of 3--6 feet, less plastic than its congeners, is confined to a moist soil frequently extending its colony on to the tide-flooded mud-banks projecting into the stream and covering them with a dense exclusive growth. Though tolerant of periodical tide-flooding, this species is not strictly halophytic, as it forms comparatively large colonies in the fluvial mud at the head of the marsh. *M. styphelioides*, and *M. linariifolia*, do not reach their optimum growth in the *Casuarina* forest, as they are dominated by the latter which outgrows them, but on the Wianamatta Shale flats in the Bankstown-Cabramatta districts these Tea-trees attain an arboreal growth equal to that of the *Casuarina*. Both *Melaleucas* are occasional on the local sandstone in swampy places but neither can maintain more than a shrubby growth on the dry sandstone hillsides. *M. nodosa* attains its individual optimum in the *Casuarina* forest where the canopy formed by its taller associate compels it to ascend to obtain light, but its maximum communal growth is reached on the shale flats where, though inferior in height, it spreads laterally, covering areas several acres in extent with an exclusive thicket. It is also capable of maintaining a vigorous but less compact colony on the Hawkesbury Series, both on the rocky ocean escarpment and the landward sandhills. *M. ericifolia* is unable to accompany its swamp associates to the dry shale flats but a reddish-purple flowered variety, var. *erubescens* Benth., mingles with the other *Melaleucas* in the Clyde-Auburn district at a distance from the marsh. Of the Tea-trees noted, mature seeds sank within 12 hours.

The Blackthorn, *Bursaria spinosa* Cav., a spiny shrub endemic within the Commonwealth, has a sparse representation in the *Casuarina* forest and occurs in company with *Melaleuca nodosa* on the shale flats, where it congregates in large colonies. These shrubs are also frequently associated on the sandstone hills. The *Bursaria* is exceptionally rigid in its habit of growth which varies but slightly under widely differing conditions of soil and



moisture. Another xerophytic shrub with a coastal range in southern New South Wales, Victoria and Tasmania, occasional in this habitat, is the heath-leaved *Kunzea corifolia* Reicheb., but its preference for a more brightly illuminated station is shown by its greater frequency and larger colony in an open situation. The *Kunzea* maintains its association with the *Bursaria* and *Melaleuca nodosa* throughout their several habitats and reaches its maximum communal growth on the shale flats.

In a *Casuarina* forest at Cook's River on a clayey alluvium flat on the western side of the Illawarra Road, the trees on the landward side have been felled, the undergrowth cleared, and the land laid down in pasture. The soil nearest the river is too salt for the Couch and Buffalo grasses, of which the sward is composed, and a broad band of *Sporobolus virginicus* is established along the river margin, extending inland until the drier conditions and reduced soil salinity become sufficiently favourable to the pasture grasses to enable them to resist further encroachment. The original vegetation is reappearing, and already some of the shrubby species have recaptured small areas and are driving back the introduced vegetation, especially on the river front where the trees were not disturbed. In the habitat subject to the clearing operations several aliens have established colonies, temporarily replacing the natural undergrowth. The Lantana, *Lantana camara* L., an introduction from South America, whose usefulness as a producer of humus on large areas of unoccupied land in Northern New South Wales and Queensland has been somewhat dubiously championed, has here invaded the forest with a weak growth. An aggressive coloniser in poor but well-drained land, it is unable in this swampy soil to form its customary thicket, breaking up into small clumps or individual bushes as it advances towards the river, and offering little resistance to the oncoming shrubby indigenous vegetation. The Lantana is indebted to birds for its distribution, its fleshy fruits affording them a tempting bait.

The Poke-weed of North America, *Phytolacca octandra* L., a succulent herbaceous perennial with broad mesophytic leaves, which has a wide range as a ruderal weed in most tropical and subtropical regions, has established a colony on the flank of the Lantana. The factors of shade and moisture obtaining in the habitat favour the development of the Poke-weed and it is not detrimentally affected by soil salinity, but its soft yielding frame

offers no obstruction to the shrubs which are driving it back as they advance. This is one of the first weeds to appear on newly-cleared land, especially in places where the previous vegetation has been destroyed by fire. It soon becomes exhausted in a habitat and dies out, a phenomenon not infrequently noted among herbaceous weeds. The fruits of the Poke-weed were found in the stomachs of the following Australian birds (38) - Peaceful Dove, *Geopelia placida*, Yellow-throated Scrub-Wren, *Sericornis barbara*, Silver Eye, *Zosterops coerulescens*, Yellow eared Honey-eater, *Ptilotis chrusotis*.

*Solanum auriculatum* Ait., a tropical American herbaceous perennial with several vernacular names each obtaining a more or less wide acceptance, is represented by a few individuals whose behaviour is somewhat similar to that of the Poke-weed, though it is not so widespread. The Wild Cotton-plant *Gomphocarpus fruticosus* R. Br., introduced from South Africa, which has also secured a footing in the forest will be more difficult to displace than the two preceding species, its tough fibrous stems and compact formation presenting a formidable line of defence. As it advances, the shrubby *Melaleuca ericifolia* is overcoming the *Gomphocarpus* in the swamp but cannot follow it on to the dry hillside. A coma of silky hairs is appended to the seeds of the *Gomphocarpus*, but their attachment is weak and they are of no value for flight. The seeds sink within a few hours.

In a *Casuarina* forest at the head of the saltmarsh at Woollooware Bay (Cronulla), the Bramble, *Rubus fruticosus* L., has established a thicket and initiated the invasion of a slightly raised, comparatively dry flat, exterminating all except the arboreal vegetation in its onward march. The Bramble is advancing in the direction of a colony of *Melaleuca ericifolia* which has entered the flat from the swamp. When the two formations come into contact, the Bramble, with its effective offensive equipment, will dominate the *Melaleuca*. Its firm but supple canes, furnished with broad horizontally-arranged leaves, will run over the tops of the *Melaleuca* bushes, building a thick screen and depriving them of light, its powerful rhizomes meanwhile forcing a passage among the shallow roots of its opponent, competing with them for nutrition and sapping their vitality. Attacked both above and below ground, the *Melaleuca* will be compelled to retreat until the habitat becomes too moist for the

Bramble. When this station is reached their respective boundaries will be regulated by the fluctuating water supply. The Bramble is incapable of building a thicket sufficiently high for the suppression of the taller *Melaleucas*, but if left undisturbed, will eventually displace them, its close investment preventing sexual reproduction—their only means of renewal—as no seedlings could survive in the Bramble thicket. The investment by the Bramble also operates unfavourably to the *Casuarina*, whose seeds, though provided with a wing, are not, as previously shown, adapted for a lengthy flight.

The Chinese Box-thorn, *Lycium chinese* Mill., is represented in the *Casuarina* forest by a scattered colony, discarding in this station its customary chapparal growth. At Lady Robinson's Beach, the Box-thorn has demonstrated its halophytic tendencies and exposure-resistant capacity, by extending in belted formation along the verge of the frontal embankment of the dune. Its hardy growth and divaricate habit have encouraged its cultivation as a hedge plant, but its adaptability has, in many places, destroyed its usefulness as it has spread over the pastures and is difficult to eradicate.

The undergrowth in the muddy fluvial station in the *Casuarina* forest is largely herbaceous, the dominant species responding to the xerophytic conditions, lack of aeration and acidity, by the production of leaves and stems with a fibrous or leathery texture. The keenest competition in this station occurs among the low growths in the flooded depressions, the taller plants usually forming loose clumps, or occurring as isolated individuals, on the slightly elevated ground surrounding the depressions. Several species have developed a trunk-forming habit with the object of raising the crown of the rootstock—from which the tender young shoots emerge—above the level of the occasional flood-waters. Of these the most prominent is a giant Tussock-forming Sedge, *Gahnia psittacorum* Labill., endemic in the Commonwealth, which erects a mound at its base, its bulky rhizomes, whose twisted arms arise and project in every direction, obstructing and retaining debris from the passing flood. These mounds form a special habitat and are occupied by a few selective minor herbs whose requirements are a rich permeable soil with a constant supply of moisture. The distribution of *G. psittacorum* is the work of birds, chiefly Parrots, as the specific name indicates, though other birds are in some measure responsible for its dis-

persal, the seeds of this Sedge forming part of the stomach contents of *Corcorax melanorhamphus*, the White-winged Cough (38, p. 94). The seeds in an early stage of maturity are bright red, changing when fully ripened to a dull brown. They are shed from the glumes while still highly coloured and hang temptingly suspended by the elongated staminal filaments. As the colour fades, the shrinking filaments draw the seeds inwards to the rachis. The red (unripe) seeds sank directly, the dry, brown, fully-ripened seeds floating for several days. This giant Sedge is present in the fluvial station in the saltmarshes and in swamps and watercourses throughout the district.

The only local species of either *Gahnia* or *Cladium* whose fruits have more than a few days' flotation is *Cladium jamaicense* Crantz, (*Cladium (Gahnia) mariscus* (F. v. M.) R. Br.), a cosmopolitan species listed by Guppy (13, 537) as having a flotation of several months. Seeds tested by the writer were immersed 26th August, 1918, and are still afloat (28th June, 1919). Though its fruits have every facility for dispersal by water, this widely ranging species is indifferently represented in the Port Jackson district. It is well established on the mudbanks in the fresh waters of the upper reaches of Duck River and in the broken headwaters of several arms of George's River at Oatley, etc., and was collected at Cook's River by Mr. A. H. S. Lucas. Its inadaptability is disclosed by its failure to spread along the course of these rivers and colonise the numerous freshwater swamps and lagoons with which they are more or less connected.

*Blechnum serrulatum* Rich., a hardy fern which extends from tropical America to the Malayan Archipelago, is frequently associated with *Gahnia psittacorum*, erecting a limited brake on the mounds at its base and raising its fronds above the floodwaters on short rhizomatic trunks. When growing in a peaty bog, the *Blechnum* usually chooses a station near the margin where the surface is only occasionally flooded. In this habitat the necessity for uplift is removed and the trunk formation is discarded, the young fronds springing directly from the crown of the tuft at the ground level. In some of the local bogs the *Blechnum* has taken possession of this zone and extended along the peaty margin in a broad band, restricted on the landward side by the dry bank and regulated in the swamp by the depth of water. An example of this banded formation occurs at Maroubra Bay in the margin of the swampy lagoon at the rear of the beach.

The Bead-fern, *Gleichenia dicarpa* R. Br., an Indo-Malayan species which extends to Tasmania, is occasional in this station, frequently associated with *Dryopteris punctata* (Thunb) C. Chr., a tropical species which reaches extra tropical latitudes in southern regions. Both ferns are limited to small clumps in this station but in the peat-bog, their preferential habitat, their formations are more extensive, the Bead-fern in some of the local swamps building a tangled brake 2--3 feet high, and several acres in extent, overrunning the smaller Cyperaceous and other herbaceous growths. In the frequent encounters between these ferns the *Gleichenia* prevails in the flooded areas, its wiry trailing stems sprawling over the rigid frondage of the *Dryopteris* and smothering it. As it advances to the drier station it weakens and is unable to support a heavy aerial growth. The rhizomatic system of *Dryopteris* is stouter than that of the *Gleichenia* and when the formations meet it is able to hold its slender but sinewy opponent at bay by arresting the further progress of its rhizomes. These ferns may be observed engaged in such a competition in a peaty swamp in Centennial Park.

The Bracken, *Pteridium aquilinum* (L.) Kuhn., is less tolerant of a wet soil than its confreeres and does not proceed far into the fluvial zone. Though frequently found in close proximity to tidal waters, the Bracken is not a halophyte, its most vigorous colonies occurring in non-saline soils, and it especially favours a permeable, sandy, well-drained soil. Its avoidance of a calcareous soil has been noted by many writers. *Goodenia ovata* Sm., a shade and moisture loving species—endemic in the Commonwealth—forms tangled patches on the margins of the depressions, the weak stems of the plants interlacing their branches for mutual support. Though tolerant of a degree of salinity, the *Goodenia* is equally suited in a freshwater station. Seeds of *G. ovata* sank within 24 hours.

The Tall Corn Flag, *Gladiolus cuspidatus* Jacq., whose station in its native country (South Africa) is the coastal sand-dunes, was noted in the tidal zone in the saltmarshes at Tempe and Buffalo Creek. It is one of the few bulbous plants found in saline stations and is well established in both marshes. The rootstock, a globose corm protected by a tunic of matted fibre, produces a cluster of bulbels which aid in the distribution of the plants. The winged discoid seeds floated for six days. A succulent-flowered Orchid, *Cryptostylis longifolia* R. Br., which

also has a tuberous rootstock, is occasionally associated with the *Gladiolus*, and they were noted in close proximity in a peaty swamp in Centennial Park.

The Fox-tail Grass, *Polypogon monspeliensis* Desf., an immigrant from the Mediterranean, enters the various herbaceous associations on the border of the salt plain, the flaccid tufts accommodating their growth to the pressure of their hosts by a vertical uplift. In a close sward of Couch or Buffalo this short-lived grass makes a weak growth a few inches high, but in an open formation of *Cotula coronopifolia* in the fluvial mud or on the mounds at the base of the *Casuarina* trunks, it reaches a height of 1½-2 feet. An Australian Composite, *Epaltes australis* Less., a fleshy prostrate perennial with dull brown rayless (discoid) flowers, forms a scattered colony on the margins of the depressions in the vicinity of the salt plain. This weedy herb is rarely subjected to competition as it is tolerant of a sour soil and usually occupies a habitat shunned by other herbage. It has established numerous colonies on the ill-drained Wianamatta Shale flats in the Fairfield-Canley Vale district. The achenes of this species sank within 24 hours.

*Jussieuia repens* L., a cosmopolitan perennial, creeps in the mud or builds up a mass of matted herbage in the shallow pools. When growing on the mud or in shallow water the *Jussieuia* develops breathing roots on the submerged rhizomatic stems in the interstices between the joints from which the true roots emerge. When floating in deeper water the plants are frequently beset with small bladder-like cavities (vesicles) around the base of the leaves, which are occasionally present in sufficient numbers to sustain the stems. *Paspalum distichum* L., a cosmopolitan grass with a creeping habit, builds up a thick sward in the shallow depressions. Bailey\* separates this species into two distinct varieties, *normale* and *littorale*. The former he describes as a broad-leaved grass which grows in fresh water and the latter a narrow-leaved form confined to brackish swamps. This distinction was noted locally, the plants growing in fresh water showing a broad lush (mesophytic) flag, and those in the brackish station the tough wiry leaves of the xerophyte. In his Manual of the Grasses of New South Wales, J. H. Maiden gives some interesting ecological references, climatic and edaphic,

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\* Queensland Flora, vi., 1902, p. 1814.

to this grass, together with valuable economic notes. Various common names have been given to this species but the var. *normale* is perhaps best known as Water-Couch, and the var. *littorale* as Sea-side Millet. During its active growing stage—it is an æstival grass—it banks up a mass of divaricately-branched herbage which overruns the intrusive annuals that have taken advantage of its resting period to enter its sward. The supremacy of the *Paspalum* in the brackish pools is frequently disputed by *Juncus prismatocarpus* R. Br., a perennial rush which adopts a similar arrangement of its colony. The formations of the grass and rush are evenly matched in height, density of formation, and mechanical structure, their respective rhizomes, which feed on the same plane, maintaining the equality of their competitive equipment. When colonising a new habitat, which may have arisen through a favourable alteration in the depth of water—the shallowing of a deep pool, or the flooding of a dry station—primary possession determines their relative boundaries. Their joint occurrence in a pool is most frequent in the zone between the fresh and brackish waters, the *Juncus* exhibiting a greater partiality for salinity than its associate, though equally capable of forming a sward in fresh water.

The Mat-grass, *Rotbelleia compressa* L. f., an Asiatic species which has spread along the coast of Australia and reached Tasmania, is a decumbent perennial with weak culms, which elongate and assume a straggling habit when growing among rushes or the taller Cyperaceous plants. Normally a swamp-dweller, the Mat-grass can adapt itself to comparatively dry conditions and is not averse to a degree of salinity. At Buffalo Creek (Lane Cove), a vigorous growth of this grass has ranged behind a band of *Cladium junceum* on the border of the marsh. In this station it is able to maintain the integrity of its formation, but in a dry habitat its density is broken and intruded by the Common Couch and other lawn grasses.

Two flaccid perennial Sedges, *Scirpus inundatus* Poir., and a close relation, *S. prolifer* Rottb., occasionally join forces in the invasion of a shallow pool in the fluvial station, their weak stems mingled in a ramifying growth. They are preferably freshwater plants and do not proceed far into the brackish zone. *S. prolifer* frequently produces a proliferous growth on the tips of its stems—simulating vivipary—which roots when it reaches the ground, affording the plants some assistance in the exten-

sion of the colony. The seeds of both species sank within 24 hours.

*Philydrum lanuginosum* Bks., a succulent perennial which ranges from China to Victoria, is common in the brackish pools. It is also well represented in freshwater pools and swamps and shows no appreciable alteration in either station. In the shallows its growth is dwarfed, the tufts attaining their tallest growth in permanent water 2--3 feet deep. The small seeds sank within 12 hours. The Australian Violet, *Viola hederacea* Labill., creeps on the banks of the pools or occupies the mounds at the base of the *Gahnia* and *Casuarina*; *Commelina cyanea* R. Br. trails over the low sedges and other herbaceous growths; *Goodenia paniculata* has also a limited representation in this station. The three above-mentioned species are preferably freshwater habitues. The Creeping Monkey Flower, *Mimulus repens* R. Br., spreads a small mat of one to a few individuals on the ridges in the saline area, occasionally invading the salt plain in moist places. It was noted on the tide-flooded mud-banks in Cook's River—an exclusive habitat—forming small patches. In both stations the *Mimulus* is associated with *Cotula reptans*, also a mud-creeper with a meagre representation. *C. reptans* establishes its largest formations in the coastal lagoons, Curl Curl, etc., and is less tolerant of a freshwater station than its associate. *Limnanthemum geminatum* Griseb., has a similar range of salinity to *Cotula reptans* and is also common in the coastal lagoons, a banded formation of this species occupying a distinct zone on the shallow margin of the Narrabeen lagoon. A broken colony was also noted in the less saline mud of a *Casuarina* forest at Cronulla, its disintegrated membership evincing its antipathy to the semi-aquatic habitat. That the reduced salinity is not the cause of its weak growth is shown by the flourishing colonies it forms in freshwater creeks and pools.

Two species of *Hydrocotyle*, *H. hirta* R. Br. and *H. asiatica* L., frequent the muddy depressions, but do not reach the salt plain. *H. hirta* requires more moisture than its congener, displaying a preference for a muddy habitat, the latter making a more robust growth in a turfy lawn. Both are preferably freshwater habitues. The Mullumbimby Couch, *Kyllingia monocephala* Rottb., forms a close sward on the verge of the pasture on the marsh boundary slopes where it is frequently associated with *H. asiatica*; both species spread into the lawn,



the *Kyllingia* weakening as the saturation decreases. The latter is a tropical species, reaching its southern limit in New South Wales. Its luxuriant growth on the rich alluvial flats on the northern rivers has gained it an unenviable notoriety among the dairy farmers, who are responsible for its vernacular name.

The Small Loosestrife, *Lythrum hyssopifolium* L., a weedy annual with a cosmopolitan range, chiefly maritime, reaches its optimum in a ditch or shallow pool, but attains a fair growth in the pasture of the *Casuarina* forest. *Haloragis micrantha* R. Br., a twiggy, depressed undershrub, indigenous in Japan and New Zealand and extending northwards along the Australian coast to Queensland, is occasional in the fluvial mud, its short stems appressed to the moist soil with the flowering branches held erect, raising the inflorescence above the water line.

Two small rushes, *Juncus bufonius* L., a cosmopolitan annual, and *J. plebius* R. Br., a perennial confined to Australia, are represented in the pasture. *J. bufonius* requires more moisture than its associate and can tolerate a greater degree of salinity, frequently intruding the herbals in the brackish station, and developing a broken, short-lived sward. *J. plebius* has a scattered formation with rarely more than a few individuals in each tuft. It is occasional in the sour clayey soils in the Bankstown-Cabramatta district where it is joined by a diminutive Sedge, *Cyperus tenellus* L., an annual with the growth habit of *J. bufonius*, a native of South Africa with a southerly range along the Australian coast from New South Wales and extending to New Zealand.

A Malvaceous perennial introduced from South America, *Modiola multifida* Moench., creeps through the pasture, rooting at short intervals and starving out any weak herbs in the vicinity of its closely-knitted carpet. In the Couch lawn, its creeping stems are forced upwards and it is unable to form a mat, the long runners trailing over the sward.

*Soliva sessilis* Ruiz & Pav., a flaccid annual with finely dissected leaves and a low decumbent growth, dominates during its active season large patches of the Couch lawn on the marsh boundary. The creeping stems root freely, forming an intricate mat and suppressing the Couch, a few blades only of the grass struggling through to the light. In St. Luke's Park, at the head of the saltmarsh in Hen and Chickens Bay, a Couch lawn

was invaded by this weed which took possession of a portion of the lawn on the marsh front about an acre in extent. Its optimum was reached in midsummer when hardly a blade of grass could be seen in its carpet, but when again visited in midwinter not a vestige of the *Soliva* was visible and the Couch dominated the recently invaded area. A congener, *Soliva anthemifolia* R. Br., also of annual duration and with similar foliage is less aggressive, rarely spreading over more than one or two feet of turf during its period of activity. *S. sessilis* succeeds best in a sandy soil and is tolerant of moderately dry conditions, its congener displaying a preference for a moist clayey alluvium, neither advancing into the brackish station on the margin of the salt-plain. *S. sessilis* was first recorded for Australia by Maiden and Betehe\* and was figured and described by Maiden†. It is not known when *S. anthemifolia* appeared in Australia, but it is viewed as a doubtful member of the native vegetation. Both species are indigenous in South America. The distribution of the seeds of *S. sessilis* is probably carried out by animals, the pointed dart at the apex of the achenes piercing their skins, or the marginal irregularities becoming entangled in their coats. The achenes of *S. anthemifolia* emit mucus when wet and would adhere to the plumage of birds. In both species the achenes have but a few hours' flotation.

Two Buttercups, *Ranunculus muricatus* L., a tufted annual introduced from the Mediterranean region, and *R. rivularis* Bks. and Sol., a stoloniferous perennial, a native of Australia which extends to New Zealand, meet in the boundary pasture. Both species find a limiting factor in this station, insufficient moisture retarding the progress inland of *R. rivularis*—normally an aquatic, with finely dissected leaves—which reaches its highest stage of development when submerged. *R. muricatus* is precluded from advancing towards the salt plain by the salinity of the station. The latter clears a space for its tufts by spreading its stiff basal leaves in the form of a rosette and overlying the grass in its vicinity. Its associate, on the contrary, is pressed by the stouter herbage into an upright growth, its weak foliage reclining on the sward. Large colonies of *R. rivularis* occur in the muddy flats on the banks of Cook's River, *R. muricatus*, in its season, spreading over the inland Couch sward. The

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\* These Proceedings, xxiv., 1899, p. 646.

† Agric. Gazette N.S.W., 1917, p. 183.

evidence points to the distribution of the Buttercups by birds. The protuberances which cover the flattened sides of the fruits of *R. muricatus*, and endow it with a specific name, impart a rough surface to the achenes when dry, which would cause them to catch in the plumage of birds, or to adhere to their muddy feet. The achenes of this species sank within 12 hours.

The Rib-herb, *Plantago lanceolata* L., a tufted perennial with a wide distribution in temperate countries, is frequent in the station selected by *R. muricatus*, and behaves in a similar manner. Hooker (24, p. 271) notes that the seeds of this species have a mucilaginous testa.

Several Docks of which the Curled Dock, *Rumex crispus* L. and the Clustered Dock, *R. conglomeratus* Murr., are the most frequent, form tufted colonies in the boundary pasture. These aliens have a perennial rootstock and a fusiform tuberous taproot which descends to a considerable depth in the sour soil where no competition is encountered. During their resting period the tap-roots accumulate a large supply of food which is greedily absorbed by the plants in the growing season. When the active growth commences the tufts enlarge—the Docks employ the same method as that practised by *R. muricatus* to secure expansion—and stout leafy stems arise from the crown of the rootstock upon which the inflorescence is elevated. After fruiting, the aerial portion of the plant dies and the tuft is reduced to a small rosette. The Sheep's Sorrel, *Rumex acetosella* L., is occasional in this station where, though not mechanically aggressive, it maintains a position owing to exceptional tolerance of soil acidity. Its antipathy to a calcareous soil has been frequently noted. The Sorrel has replaced the deep taproot of its congeners the Docks with the shallow rhizomatic growth adopted by most of the marsh herbs. Seeds of the Sorrel either enclosed in the perianth or separated from it sank within 24 hours.

*Melilotus parviflorus* Desf., the Scented Melilot of Europe, an adaptable annual with an erect growth habit, has no difficulty in securing a footing among the pasture herbs, its deep taproot descending to feed below their root systems and its aerial growth ascending above them. In moist, permeable, non-saline soil the plants may rise to a height of 3 feet, but at Cook's River a small colony was noted on the margin of the salt plain, debilitated by the excessive salinity, flowering and

fruiting at a height of 1 to a few inches (Plate xxviii., fig. 24). *Polycarpon tetraphyllum* Loefl., a diminutive mat-forming cosmopolitan annual, common in sandy maritime stations, can only maintain a position in the sward of a resting species or on a vacant space, its weak growth offering no resistance to the pressure of its stronger associates. On a newly reclaimed area at Cook's River it was the only vegetation present, dotting the ground with isolated mats some of which extended to 1 foot in diameter. The persistent bracts and sepals of the closely-packed flowers, which turn red in fruit, presented a striking contrast to the pale rain-leached sand.

The Petty Spurge, *Euphorbia peplus* L., an introduced annual with an upright habit, is forced into a rank growth by the damp shady conditions obtaining in the lax pasture of the *Casuarina* forest, its weak lanky stems supported by the surrounding herbs. In common with many of its congeners, the Spurge secretes a milky latex. The Pimpernel, *Anagalis arvensis* L., another cosmopolitan shade and moisture loving annual, with a decumbent growth, also frequents the *Casuarina* forest, both the blue and scarlet flowered varieties trailing succulent stems through the pasture. *Fimbristylis diphylla* Vahl., a tufted perennial sedge common in most warm regions, is occasional in the pasture where it is non-competitive, its flaccid basal leaves folding vertically round the stem when pressed by the grasses which it intrudes. *Chenopodium album* L., the White Goose-foot of Britain, an adaptable weed with a cosmopolitan range, enters most of the formations from the boundary of the salt plain inland. Its lengthy taproot penetrates the marsh mud undeterred by either acidity or salinity, and can develop an equally vigorous growth in a comparatively dry station if the soil is permeable. The plants maintain their positions in the formations which they intrude, by building a tall, spreading, leafy screen which acts as a deterrent to approaching competitors. Seeds of *Chenopodium* spp. were frequently identified in the stomach contents of Australian birds (38).

The slopes on the boundary of the marsh are usually clothed with a Couch lawn which is intruded by numerous ruderals, chiefly Clovers, Medicks, Grasses and Thistles. The Clovers, *Trifolium* spp. and Medicks, *Medicago* spp., are chiefly creeping or procumbent herbs and make their maximum growth in the moist meadow at the base of the slope, gradually weakening as

they ascend the dry hillside. These plants make a close matted growth in the lawn, several species frequently associating, subduing the Couch, and taking possession of small areas during their active growing season. After fruiting, the annuals disintegrate and the perennials reduce their mat, the Couch resuming the vacated area. The ruderal grasses are chiefly annuals and range from the meadow at its base to the crown of the slope. They are mostly shallow rooting and scantily tufted and do not interfere to an appreciable extent with the Couch. An exception is provided by the Barley-grass, *Hordeum murinum* L., which develops a powerful offensive mechanism, its elbow-shaped stems forcing back and depressing the weaker stems of the Couch and forming a radial patch in the lawn.

In addition to the introduced grasses several indigenous species of perennial growth are represented on the slopes and where undisturbed soon re-establish their supremacy. The Kangaroo-grass, *Themeda Forskalii* Hack. var. *imberbis*, a tufted grass, maintains a comparatively large colony, its thick tussocky growth smothering the adjoining herbs. The Blady-grass, *Imperata arundinacea* Cyr., a rhizomatic species, also covers considerable areas, its aggressive underground stems and tall broad aerial flag forming a strong offensive and defensive combination. The Blady-grass is frequently associated in this station with the Bracken Fern, *Pteridium aquilinum* (L.) Kuhn. The Thistles range throughout the slopes, their strong, rough, fibrous stems defending the colony from aggression by the taller herbs and their heavy basal rosettes suppressing the lower growths. *Scirpus nodosus* Rottb., a tall slender-stemmed rush common on the shore-line, has a limited representation on the hillside. A series of smaller and weaker herbs in the Couch lawn includes the Common Chick-weed, *Stellaria media* L., and the Mouse-eared Chick-weed, *Cerastium vulgatum* L., both introduced weedy annuals, and *Cotula australis* J. Hook., an Australian perennial. The members of this group do not form large colonies nor enter into competition with the Couch, their flaccid stems and leaves trailing over the grass which they are not firm enough to displace nor sufficiently close to overshadow.

Of the arboreal vegetation on the slopes the White Honey-suckle, *Banksia integrifolia* L. f. descends into the fluvial zone on the boundary of the *Casuarina* forest. In their customary habitat on the exposed shore line these trees are compressed into

a narrow conical growth but in this moist sheltered station they develop an umbrageous habit. At Hen and Chickens Bay a group of Turpentine trees, *Syncarpia laurifolia* Ten.—symptomatic of the shale—was noted on the hillside at no great distance from the marsh. The River Mangrove, *Aegiceras majus* Gaertn., is indifferently represented in the local marshes, the largest formation observed occurring in a marsh on the southern bank of Port Hacking River, near the entrance. This species is more frequent locally on the banks of tidal rivers than in the marsh proper, several clumps occurring on the banks of Cook's River, and on the banks of George's River at Como, always ranging behind the Grey Mangrove. In the latter locality several trees of the Grey Gum, *Eucalyptus punctata* DC., were noted in a formation of *Juncus maritimus* on the muddy river bank. The halophytic tendency of the Grey Gum is shown in a record of its habitat by J. H. Maiden,\* "Kuring-gai Chase, at edge of salt-water, near house-boat. W. F. Blakely." A bush of *Viminaria denudata* Sm. had also penetrated the ranks of the *Juncus* formation a considerable distance into the tideway.

In the vicinity *Polygala myrtifolia* L., an aggressive, soft-wooded shrub introduced from South Africa as an ornamental garden plant, has escaped from cultivation and spread round the sides of an amphitheatre-shaped gap in the river bank which had been cleared and grassed. The original indigenous vegetation is already reasserting itself, the Native Grapes, *Vitis Baudiniana* F. v. M., and *V. hypoglauca* F. v. M., climbing over the *Polygala* bushes and enveloping them.

On the rock benches overhanging the river a series of succulent epiphytes form small clustered colonies. Of these, the somewhat rare *Calandrinia Pickeringi* A. Gray, and *Peperomia leptostachya* Hk. et Arn., are occasional, their associate *Plectranthus parviflorus* Henck., occurring more frequently and forming larger colonies. Though these herbs are usually found in shady situations, they can flourish under strong illumination, occasionally growing on rock ledges exposed to direct sunlight for the greater part of the day. The two former species rarely depart from the epiphytal habit of growth but the *Plectranthus* is more adaptable and on occasion becomes a troublesome weed in cultivated land.

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\* Critical Revision of the Genus *Eucalyptus*, iii., p. 197.

Along the river banks several trees and shrubs were noted which, though found in situations far removed from tidal waters, exhibit a measure of partiality for a saline environment. *Acacia falcata* Willd., has lined the banks of Bray's Bay on the Parramatta River with a belted shrubbery. The soft-wooded *Clerodendron tomentosum* R. Br., grows almost to the water's edge at Cook's River and was also noted on the banks of George's River near Como. *Glochidion Ferdinandii* J. Muell., has formed an extensive grove in the vicinity of the bridge over George's River at Como, and a smaller colony near the tideway at Fig-tree, Lane Cove River.

Of the plants noted in the marsh proper the following are found in the saltmarshes of the interior:—*Samolus repens*, *Suaeda maritima*, *Spergularia rubra*, *Triglochin striata*, *Juncus maritimus*, var. *australiensis*, *Sporobolus virginicus*, *Mesembryanthemum aequilaterale*, *Tetragonia expansa*, *Wilsonia Backhousii*.

The specimens mounted to illustrate this paper will be presented to the Sydney National Herbarium.

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## EXPLANATION OF PLATES.

## Plate xvii.

Fig. 1.—Saltmarsh fringed by a band of reeds (*Cladium junceum* and *Juncus maritimus* var). *Salicornia* meadow in the middle distance. Buffalo Creek, Lane Cove River.

Fig. 2.—Parallel bands of *Juncus* and *Cladium* lining the marsh. *Juncus* in the tidal zone. Buffalo Creek.

## Plate xviii.

Fig. 3.—*Juncus* (drooping tufts) in tidal zone. *Cladium* (erect) on bank in swampy soil with reduced salinity. Buffalo Creek, Lane Cove River.

Fig. 4.—Intrusion of a *Juncus* formation by the *Cladium* along the course of a fresh water drainage channel, Buffalo Creek.

## Plate xix.

Fig. 5.—Salt-grass (*Sporobolus virginicus*) showing luxuriant growth in response to reduced soil salinity. Buffalo Creek, Lane Cove River.

Fig. 6.—Debilitated culms of the Salt-grass prostrate on the sterile plain, the result of extreme soil salinity. Cook's River.

## Plate xx.

Fig. 7.—*Salicornia australis* encircling a *Ruppia* pool on the salt plain at Homebush Bay.

Fig. 8.—Tuft of *Salicornia* bordering a detritus mound crowned with Salt-grass on a salt plain at Cook's River.

## Plate xxi.

Fig. 9.—*Ruppia maritima* L. lying on the mud at low tide. Band of *Triglochin striata* lining the bank of the channel, Cook's River.

Fig. 10.—Dense growth of *Ruppia maritima* awash at high tide, Cook's River near Tempe.

## Plate xxii.

Fig. 11.—Artificial environment created by the formation of a dyke at Homebush Bay permits encroachment by Seablite (*Suaeda maritima*).

Fig. 12.—Pure culture of Seablite at Homebush Bay. Debilitated mangroves in foreground.

## Plate xxiii.

Fig. 13.—Intermingled patches of *Salicornia* and Seablite clothing the salt plain at Homebush Bay. Suncracked surface in the foreground.

Fig. 14.—Stretch of barren salt-encrusted plain at Cook's River. *Juncus maritimus* on margin.

## Plate xxiv.

Fig. 15.—Meadow of *Cotula coronopifolia* (inundated) bordering a Thatch-reed formation at Undercliffe, Cook's River. *Juncus maritimus* in foreground.

Fig. 16.—Dense sward of *Salicornia* in tidal zone breaking up into mats in an attempt to invade the dry salt plain at Cook's River.

## Plate xxv.

Fig. 17.—Band of Thatch-reed (*Phragmites communis*) bisected by a band of *Scirpus littoralis* on the bank of Cook's River at Undercliffe.

Fig. 18.—Weak growth of Thatch-reed invaded by *Triglochin striata*. Salt plain, Undercliffe.

## Plate xxvi.

Fig. 19.—Forest of Swamp Oak (*Casuarina glauca*) with undergrowth of Tea-trees (*Melaleuca* spp.) at Bray's Bay, Parramatta River.

Fig. 20.—Stranded Mangroves (*Azicennia officinalis*) invaded by a grass and ruderal pasture. Cook's River.

## Plate xxvii.

Fig. 21.—*Wilsonia Backhousii* Hook. f. Stems elongating and rooting *pari passu* with the silt deposit.

Fig. 22.—Seablite (*Suaeda maritima* Dumort). Lateral roots spreading horizontally on the marsh mud.

## Plate xxviii.

Fig. 23.—*Triglochin striata* Ruiz. et Pav. Variation in height represented by relative degree of submergence.

Fig. 24.—*Melilotus parviflora* Desf. Stunted plants on salt plain 1-1½ in. high. Normal height 3-4 ft.

## Plate xxix.

Fig. 25.—*Selliera radicans* Cav. 1. Growth luxuriant, few flowered.  
2. Growth densely appressed, floriferous.

Fig. 26.—Swamp Oak (*Casuarina glauca* Sieb.).

## Plate xxx.

Fig. 27.—*Juncus maritimus* Lam. var. *australiensis*. Rhizome short. Inflorescence clustered.

Fig. 28.—*Cladium junceum* R. Br. Rhizome elongated. Inflorescence few flowered.